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MONTHLY PROGRESS REPORT

ENGINEERING PROGRAM FOR THE DEVELOPMENT OF A LIGHTWEIGHT ANTI-TANK ROCKET

FOR THE PERIOD

MONTH OF SEPTEMBER 1957

CONTRACT NO. RD-142

ORDNANCE PROJECT NO.

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Hesse-Eastern

Progress Report #9-7-50G-1

HESSE - EASTERN DIVISION

FLIGHTEX FABRICS, INC.

PROGRESS REPORT #1

ENGINEERING PROGRAM FOR THE DEVELOPMENT OF A LIGHTWEIGHT ANTI-TANK ROCKET

SEPTEMBER 1957

CONTRACT NO. RD-142

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SUBMITTED BY: HESSE-EASTERN DIVISION
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Hesse-Eastern

WORK DONE DURING MONTH OF SEPTEMBER 1957

REPORTING PERIOD 14 AUGUST TO 7 OCTOBER 1957

Authority was granted on 14 August 1957 to proceed with work on Task I. The first two weeks were spent in delineating administrative procedures, establishing separate secure working areas and planning a detailed program for the accomplishment of the work. At the end of this period, a meeting was held (23 August) with Bob and Hank at Hesse-Eastern.

At this meeting Hesse-Eastern presented a detailed program for evaluation and discussion. The program was shown on five drawings, viz., System Evaluation Program, Drawing No. D-8010, Motor Development, Drawing No. 8011, Warhead Development, Drawing No. D-8012, and Launcher Development, Drawing No. D-8013, and Fuze Development Program, Drawing No. D-8014. Bob and Hank have been supplied with copies of the above drawings.

The program as presented was approved. It was agreed that the first week of the schedule should be the week ending 6 September. It was further agreed that revisions to the program would be made periodically as the schedule unfolded.

Accordingly, work on the contract objectives began on the first week in September, 1957, which will be considered as the first week of the schedule shown on the program drawings. The work done will be described under the four program headings.

System Evaluation Program (Drawing No. D-8010)

During the first six weeks, this program has moved along on schedule with the exception of section B. 4., which is the Component Test and Evaluation of the Launcher. The delay was necessitated by the lack of clearance on Mr. I. Ritucci. However, Mr. Ritucci has since received clearance, and it is expected that the program will proceed as planned with the first week moved up to about 20 September 1957. It is still too early to tell how the three-weeks delay in the launcher program will effect the over-all launcher development schedule.

This period saw the development and flight test of the first prototype model, Evaluation Model No. 1, as well as preliminary design of Evaluation Model No. 2. A Polaroid photograph of Evaluation Model No. 1 (henceforth to be called E. M. No. 1) may be found in the rear of this report (Photograph No. 1).

The unloaded weight of E. M. No. 1 was 3.127 lbs. ave. Its maximum diameter was 2.500", length 21" with the C. G. 9 3/4" from the tail end. The motor was loaded with four monoperforated grains of M-7 propellant, head end suspended, weighing 60 grams. A dummy head having the same contour and simulating the approximate weight and C. G. of the H. E. A. T. head was used. The igniter consisted of FFFg black powder, and an M1A1 electric squib contained within a 1 mil polyethylene bag. Ignition was from the nozzle end using a cork stopper with a 3/8" hole to center the bag and restrict the throat. The round was launched through a three-foot long seamless mechanical tube, rigidly mounted fore and aft.

It should be pointed out here that a detailed discussion of the test and motor and round performance will be found in the section Motor Development Program. This section will be confined to over-all progress.

The test with E. M. No. 1 was run on 4 October 1957 and witnessed by Hank, Bob and Mr. should say Walt. ~~Ehrlich~~. Results show that at $+ 120^{\circ}F$ the average velocity was 265 ft/sec. The motor produced an impulse of 26.5 lb. sec. and a specific impulse of 200 lb. sec/lb. The important conclusion which may be drawn from these results is that the rocket motor for E. M. No. 1 is operating satisfactory, as shown by the specific impulse. (See Ref. 1).

Using the same basic ballistic parameters of the motor of E. M. No. 1, rounds can be made up to test many parts of the weapon system, thus maintaining the project on schedule.

Test results also showed that although E. M. No. 1 was stable for the first 30 feet of flight it became unstable and tumbled at about 40 to 80 yards range. It is believed that the instability was due primarily to the location of the C. G. being only 9 3/4" from the tail end. In order to expedite procurement of metal parts for E. M. No. 1, close control of weight distribution was not maintained. For example, it was necessary to double the motor wall in order to use available material and thus prevent a delay of 30 to 60 days.

The bulkiness of E. M. No. 1 through its mid-section also may have been a contributing factor to its instability, since air flow was reduced through the tail surfaces, thus minimizing the corrective force of the tail.

Using a modified E. M. No. 1, tests will be run during October in an attempt to stabilize the round. It is hoped that stability will be achieved by (1) increasing velocity to at least 300 ft/sec, (2) moving the C. G. forward and (3) by reducing the diameter of the round in its center section.

Design of E. M. No. 2 has been approximately 95 per cent completed. Manufacture of at least 100 E. M. No. 2 will be initiated as soon as test results show either a complete solution or at least the proper direction to a solution of the problem of stability.

E. M. No. 2 is essentially a refinement of E. M. No. 1. Design emphasis on E. M. No. 2 has been placed on (1) reduction of weight, (2) easier manufacture and assembly and (3) better air flow for control surface (tail). It is hoped that E. M. No. 2 will weigh 0.56 lbs. less than E. M. No. 1, or 2.6 lbs. It is very important that E. M. No. 2 weight be a minimum, since HEAT head testing may show that an increase in round O. D. is necessary in order to obtain the desired penetration.

The fuze program (Drawing No. D-8013) is on schedule. A fuze has been designed and initial static testing begun. Test results have shown (1) sufficient sensitivity, (2) sufficient energy for functioning, i.e., firing the detonator with the firing pin spring and (3) a functioning time of approximately 0.001 sec. Tests are planned for the immediate future to investigate (1) set-back of inertia element with detonator in line, (2) functioning on target, (3) crush-up vs. functioning time and (4) arming, i.e., set-back of inertia element and rotor functioning.

As previously mentioned the launcher program (Drawing No. 8013) is about three weeks behind schedule. Design work has been completed on the prototype launcher. Parts for the launcher mounted igniter have been ordered for experimental testing. The remaining components are being detailed and will be ordered in the near future. Thirty launcher tubes for initial mock-up and testing have been ordered and delivery is expected daily.

The Warhead Development Program (Drawing No. D-8012) has proceeded on schedule. An HEAT head has been design, and 25 sets of components manufactured. (See Photograph No. 5 in Appendix). The head has a maximum diameter of 2.500". The shaped charge liner is a double angle drawn copper cone with a thickness taper of .021" per inch of length along the cone axis for the larger angle wall (58°) and a constant wall thickness for the smaller angle wall (22°). The base diameter of the copper liner is 2.435". The Composition B load shall weigh approximately 0.8 lbs. Initiation of the Comp B will be by a tetryl booster 0.500" thick by 1.500" in diameter. The booster is initiated by the T-57 detonator of the fuze.

The first lot of 26 HEAT heads will be loaded at the Hunter Corporation of Bristol, Pennsylvania, under the supervision of Mr. Dominick Nero of Hesse-Eastern Division. Loading should be accomplished during the week of 20 October, with static and flight tests at Camp Edwards following as soon as possible thereafter.

Motor Development Program (Drawing No. 8011)

In designing a motor for E. M. No. 1, the following requirements were used as a starting point:

1. Range 100 yards with minimum trajectory.
2. Carry pay-load capable of penetrating 10" of armour.
3. Minimum launcher length for portability.

Considering No. 1 above, a typical round velocity may be determined by using the formulas for the trajectory of a projectile, neglecting air resistance. The formulas are:

1. $X = \frac{v^2}{g} \sin^2 \theta$

2. $h = \frac{v^2}{2g} \sin^2 \theta$

Where X = range = 300 ft.

v = velocity

h = maximum height of trajectory

θ = angle of elevation

Assuming $\theta = 5^{\circ}$, then from 1. the round velocity is 236 ft/sec and from 2. the maximum height of the trajectory is 6.6 ft.

A trajectory height of 6.6 ft. seems satisfactory, since most overhanging objects such as trolley wires, signs, lights are higher. However, in order to maintain 6.6 ft height, the velocity in vacuum of 236 ft/sec must be raised to compensate for air drag. It is felt that by arbitrarily postulating a velocity of 300 ft/sec the 6.6-ft. height should be met. Therefore, a round velocity of 300 ft/sec, although approximate, has been determined.

An approximate round weight can be obtained by evaluation of requirement 2 above viz., carry pay-load capable of penetrating 10" of armour. The most efficient way to penetrate 10" of armour is to use the principle of the shaped charge. Experience (Ref. 2) has shown that the depth of penetration is nearly proportional to the O. D. of the warhead (Ref. 3), all other factors being equal, i.e., proper stand-off, cone design, etc. Now a 3.5" shaped charge warhead weighing 3 lbs. (Ref. 2) can penetrate 15" of armour. Therefore, if a penetration of 10" is desired, the following proportions may be formed:

3. $$\frac{3.5''}{d} = \frac{15''}{10''}$$

or $d = 2.33''$, where d = O. D. of warhead used to obtain 10" of armour penetration

4. $$\frac{3 \text{ lbs.}}{15 \text{ in.}} = \frac{x \text{ lbs.}}{10 \text{ in.}}$$

or $x = 2$ lbs., where x = weight of warhead required to penetrate 10" of armour

Since No. 3 is not an exact proportion, assume the warhead to be 2.5" instead of 2.33" to add a safety margin to the design. Testing may show that more of a margin is necessary, but 2.5" is sufficient for preliminary data.

Consider that an efficient rocket motor (for a round of this nature) should weigh approximately 1/3 rd. of the total round weight, then, with a head weight of 2 lbs., the motor would weigh 1 lb. The total round weight is then 3 lbs. Through design refinements, it may be expected that the approximate theoretical weight of 3 lbs. may be reduced. A reasonable assumption is that the round would weigh 2.9 lbs.

From an evaluation of requirement 1. and 2., the following round characteristics have been tentatively established - O. D. 2.5", weight 2.9 lbs., velocity 300 ft/sec. These figures will be the basis upon which the rocket motor is designed.

Now, the impulse or momentum of the rocket is

$$5. \quad I = \int_0^t F\,dt = mv, \text{ where } m = \frac{W}{g} = \frac{29 \text{ lbs.}}{32.2 \text{ ft/sec}^2}$$

$$\text{or } I = 27 \text{ lbs. sec.} \qquad v = 300 \text{ ft/sec}$$

Specific impulse may be defined as the amount of momentum per pound of propellant. It is a measure of the total efficiency of the rocket motor, i.e., how well the motor converts the kinetic energy of the burning propellant into momentum. With M-7 propellant a specific impulse of between 190 and 230 may be expected.

Assume a specific impulse of 220 $\frac{\text{lb. (force) sec}}{\text{lb. (weight)}}$, then

$$6. \quad 220 = \frac{I}{W_p}, \text{ where } I = \text{impulse} = 27 \text{ lb/sec}$$

$$W_p = \text{propellant weight}$$

$$\text{or } W_p = \frac{27 \text{ lb/sec}}{220 \text{ lb. sec/lb}} = .125 \text{ lbs.}$$

It can be seen that by assuming a specific impulse of 220, a rather low but not minimum propellant weight has been determined. The reason for this is twofold - (1) designing to the minimum weight postulates perfect ballistic and mechanical design of the prototype which is a practical impossibility and (2) designing to a larger weight, i.e., 190 $\frac{\text{lb/sec}}{\text{lb.}}$, introduces the possibility of motor blow-ups on the prototype giving inconclusive data.

Thus, using a round weight of 2.9 lbs. and round velocity of 300 ft/sec, the three further characteristics have been determined, viz., impulse, 27 lb/sec, propellant weight, .125 lbs. and specific impulse, 220.

In evaluating requirement No. 3, minimum launcher length for portability, assume a satisfactory launcher length to be 3 feet. Then

7. $v^2 = 2as$, where $v = 300$ ft/sec (final velocity)

or $a = 15{,}000$ ft/sec^2, where a = acceleration
s = distance = 3 feet

and 8. $t = \frac{v}{a} = 0.020$ sec, where t = time to travel 3 feet

Assuming that the propellant shall be completely burnt in the launcher, then the maximum allowable burning time is 0.020 sec.

Now the burning rate of M-7 propellant is as follows:

Temperature °F	Burning Rate (R) in/sec	Motor Pressure (Approx. Mean)
-20°	1.5	3,000 psi
+70°F	2.56	6,400 psi
+120°F	3.37	8,800 psi

As can be seen from the Table, the minimum burning rate is 1.5" sec, which gives a maximum burning time. By multiplying 1.5 in/sec X .020 sec, the amount of propellant wall which is burned through in three feet is found to be 0.030". Since the grain burns from both inside and outside towards the center, then the total wall or web is 0.060".

The burning rates at all higher temperatures are greater than at -20°F; therefore, the burning distance will be less than three feet.

The following Table summarizes the round characteristics which have so far been developed:

Total Weight	2.9 lbs.
Velocity	300 ft/sec
Height of Trajectory	6.6 ft.
Impulse	27 lb. sec.
Specific Impulse	220 lb. sec/lb.
Propellant Weight	0.125 lbs.
Propellant Web	0.060"

The remaining problem consists in establishing the propellant charge configuration and motor geometry which will produce the velocity, impulse and specific impulse shown in the above Table.

In designing a rocket motor there are certain procedures which, when properly applied, determine the charge and motor configuration. These procedures consist of matching dimensions to agree with certain fundamental postulates. Since this report is not meant to be a dissertation on basic theoretical rocket design, these postulates or rules will merely be stated with no proof presented. (Proof of their validity has been shown in a very practical way by the success of the first firing test.)

In order that the maximum pressure in the motor chamber should not exceed approximately 6,500 psi at $\neq$ 130°F conditioning temperature, the ratio (K_t) of the surface area of propellant (A_{sp}) to the area of the throat (A_t) should be approximately 210.

9. $K_t = \frac{A_{sp}}{A_t} = 210$

If the gas generated by the propellant reaches the local velocity of sound at any point before the throat of the venturi, shock waves will be formed and unstable, dangerous conditions will result. To prevent this condition, the ratio of cross-sectional area available for gas flow (A_p) to the area of the throat (A_t) must be equal to or greater than 2.

10. $$\frac{A_p}{A_t} \geq 2$$

The ratio (K_o) of the outside surface area of the propellant sticks (S_o) to the cross-sectional area available for gas flow between the outside of the propellant sticks and the inside of the motor (A_o) is an indication of the gas flow conditions on the outside of the sticks.

11. $$K_o = \frac{S_o}{A_o}$$

The ratio (K_i) of the inside surface area of the propellant (S_i) to the inside cross-sectional area available (A_i) is an indication of the gas flow conditions on the inside of the propellant sticks.

12. $$K_i = \frac{S_i}{A_i}$$

The lower K_o and K_i, the better will be the flow conditions. For ideal conditions the static pressure and gas velocity must be the same on the outside and the inside of the propellant, or K_o should equal K_i.

13. $$\frac{K_i}{K_o} = 1$$

The ratio $\frac{K_i}{K_o}$ is used as an indication of how much conditions vary from the ideal. Values of $\frac{K_i}{K_o}$ up to 1.5 are reasonable.

14. $$\frac{K_i}{K_o} < 1.5$$

The ratio of K_o to K_t is an indication of how close the velocity of the gas outside the propellant sticks is to sonic velocity just before the venturi. This ratio should be kept below .65.

15. $\frac{K_o}{K_t} < .65$

The ratio of K_i to K_t is an indication of how close the velocity of the gas inside the propellant stick is to the sonic velocity just before the venturi. This ratio also should not exceed .65.

16. $\frac{K_i}{K_t} < .65$

Finally, the ratio of the maximum area (A_{ex}) of the expansion cone to the throat area (A_t) should lie between 4 and 8, using a cone angle of 30° included.

17. $C = \frac{A_{ex}}{A_t} > 4 < 8$

Using the above rules, calculations were run which produced the following charge dimensions: 4 sticks of M-7 propellant, 4.72" long, O. D. 0.700", I. D. 0.580", web 0.060", total calculated weight 57.7 grams. Specific dimensions of the motor thus developed are I. D. 1.72" (1.66 actually used), throat diameter 0.651", expansion cone diameter 1.5".

How the charge and motor configuration chosen compares with the postulates is show below:

$A_{sp} = 70.3 \text{ in}^2$

$A_t = .334 \text{ in}^2$

$d_t = .651"$

(Equation 9.) $K_t = \frac{A_{sp}}{A_t} = 210$

(Equation 10.) $\frac{A_p}{A_t} \geqq 2 = 5.7$

(Equation 11.) $K_o = \frac{S_o}{A_o} = 36.4$

(Equation 12.) $K_i = \frac{S_i}{A_i} = 36.4$

(Equation 13.) $\frac{K_i}{K_o} = 1$

(Equations 15., 16.) $\frac{K_i}{K_t} = \frac{K_o}{K_t} \angle .65 = 0.173$

(Equation 17.) $C = \frac{A_{ex}}{A_t} > 4 \angle 8 = 5.5$

The theoretical data discussed above was used as the basis for the design of Evaluation Model No. 1. Referring to photograph No. 3 in the rear of this report, the motor for E. M. No. 1 consists of a threaded adapter (or motor closure), four knurled steel studs and plate for suspending the propellant charge, an aluminum motor body, a steel throat insert, and a shrouded aluminum tail. One propellant stick is shown in photograph No. 4, mounted in a stud and plate assembly.

The original design of the motor called for using 2024 T-3 drawn aluminum tubing, having a minimum yield strength of 50,000 psi and an ultimate strength of 70,000 psi. The wall of this motor was 0.080", which was considered sufficient to withstand the maximum pressure of 6,500 psi at $\neq$ 120°F conditioning temperature. When ordering the 2024 T-3 tubing, it was found that, although listed in catalogs, it was not a stock item and would therefore necessitate a special mill run with a 30 to 60 day delivery. It was therefore decided to substitute 6061 T-6 tubing which was immediately available. The physicals for 6061 T-6 are 35,000 psi minimum yield and 42,000 psi minimum ultimate. To compensate for the reduced physicals, the wall was increased from 0.080" to 0.170".

This extra wall resulted in the final motor alone weighing 0.678 lbs. instead of the expected 0.500 lbs. It was recognized that the added weight would have two detrimental influences: one, a reduction in the theoretical velocity of 300 ft/sec and two, a rearward movement of the C. G. which may cause the round to be unstable. However, it was decided to go ahead with the increased weight since sufficient internal ballistic data can be obtained irrespective of velocity and stability.

The availability of both 2024S T-3 and 6061 T-6 tubing dictated a change of I. D. from 1.72" as calculated to 1.66. Although This would cause some change in A_p and K_o, it was felt that its influence would be negligible.

The first approach to the fabrication of the motor was to make the motor and nozzle one piece with the venturi contour being obtained by rolling from the outside and finish machine inside where necessary. It soon became apparent that tooling development time would not allow testing as quickly as desired. The design was then modified to a partial rolling of the venturi with a machined steel insert to form the remaining internal contour. This design was easily manufactured and assembled.

A dummy head was designed and manufactured for initial flight tests. The head (shown in photograph No. 2) consisted of the same ogive as the HEAT head and an aluminum cylinder having approximately the same weight and C. G. as the loaded HE head body.

To obtain propellant charges for initial tests, it was necessary to machine propellant already available at Hesse-Eastern. No problem has been experienced on machining the O. D. The I. D. has to be increased from approximately .320" to 0.380". The procedure used is to place the stick in a holding fixture, mount the fixture in a lathe, drill the I. D. and then make a final pass with a reamer. This procedure, although producing satisfactory results, is very time-consuming since the drill heats up very fast and must be withdrawn after only 3/4" to 1" of depth has been drilled. Using this procedure, approximately 10 charges can be prepared per week for flight testing within any one week. In other words, the rate of testing is limited to ten rounds per week. Referring to the various development programs, it was obvious that at this firing rate schedules would not be met after the first 8 to 10 weeks. Furthermore, it became apparent that the prime objective of the first flight tests with E. M. No. 1 should be to determine internal ballistics and fix the charge dimensions in order that a large lot of propellant may be manufactured as soon as possible.

Accordingly, 14 rounds of E. M. No. 1 with dummy head were made up for test firing at Hesse-Eastern's range at Camp Edwards. Preliminary to this test firing, the first motor manufactured was statically fired at + 120°F conditioning temperature as a rough check against failure. The test was held on 2 October 1957 without instrumentation and the motor did not fail.

Since the test was scheduled for 5 October and since assembled rounds would not be available until late in the day of 4 October, 24-hour conditioning of the rounds was not possible. Therefore, propellant charges and igniters were conditioned separately and loaded into the rounds on the morning of 5 October.

It was decided to fire the rounds at + 120°F and -20°F, since these are the extremes of operating temperature and the most critical tests for internal ballistics.

The test was performed on 5 October 1957 and witnessed by Bob, Hank and Mr. Ehrlich. Fastax camera records were made of the first 30 feet of flight from the end of the launcher.

The first 7 rounds fired (test rounds 2 - 8) had been conditioned at +120°F. The discussion and evaluation of the test results for these rounds will be discussed under three headings (1) Internal Ballistics, (2) Ignition and (3) Stability.

1. Internal Ballistics

The following table shows the data obtained on each round:

1. ROUND NO.	2	3	4	5	6	7	8	Ave.
2. Velocity = ft/sec	275	277	263	250	-----	259	---	264.8
3. Prop. Wt. (lbs)	.132	.132	.132	.132	.132	.132	---	
4. 1/2 Prop. Wt.	.066	.066	.066	.066	.066	.066	---	
5. Projectile Wt.	3.140	3.140	3.160	3.100	3.100	3.123	---	
6. Eff. Wt. = 4+5	3.206	3.206	3.326	3.166	3.166	3.189	---	
7. Impulse = lb/sec	27.4	27.6	27.1	24.6	---	25.6	---	26.46
8. Specific Impulse = lb/sec / lb	208	209	205	186	---	194	---	200.4

Literally, the above table shows external ballistics. However, by inference, if velocity, impulse and specific impulse are satisfactory, the internal ballistics of pressure and thrust should also be satisfactory.

The following table shows a comparison of calculated and measured values:

	Calculated	Measured
Velocity	300 ft/sec	265 ft/sec
Prop. Wt.	.127 lbs.	.132 lbs.
Rd. Wt.	2.9 lbs.	3.127 lbs.
Impulse	27 lb/sec	26.46 lb/sec
Specific Impulse	220 $\frac{\text{lb/sec}}{\text{lb.}}$	220.4 $\frac{\text{lb/sec}}{\text{lb.}}$

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Considering that the rounds were heavier than desired and that all rounds experienced erratic ignition (as discussed in next section), the measured velocity, impulse and specific impulse are satisfactory. Therefore, the propellant charge dimensions have been fixed and sufficient quantities ordered to cover the entire contract.

The extra round weight is due primarily to the motor being heavier than expected due to the necessity of using 6061 instead of 2024 aluminum. Both the adapter and tail were also heavier than expected. The use of a steel insert added further weight. Evaluation Model No. 2 is being designed so that the weight of the adapter, motor, studs and plate and tail assembly will be reduced. The cumulative weight reduction may exceed 1/2 lb., which would bring the round weight down to approximately 2.6 lbs. It is expected that the weight reduction will give a round velocity in excess of 300 ft/sec at $+120^{\circ}F$.

2. Ignition

The igniters for these rounds consisted of 3 grams of FFFg black powder held with a .001 mil polyethylene bag and ignited by means of an MIAI electric squib. This assembly was placed in a 3/8" hole, drilled in a 3/4" cork stopper. The stopper was inserted in the nozzle throat.

All of the test rounds exhibited delayed ignition and some had partial ignition. Delayed ignition may be defined as complete or partial ignition of the charge taking place some time after the igniter has blown out the nozzle plug. Partial ignition is defined as ignition of only a part of the charge which part burns for a discrete time before the remainder of the charge ignites to generate impulse. Proper ignition may be defined as the instantaneous burning of all of the propellant's surface area simultaneous with the expulsion of the nozzle plug and forward momentum.

Delayed or partial ignition usually gives a reduction in round efficiency, i.e., velocity. This is particularly true with partial ignition since that portion of the charge which burns before the full charge is ignited contributes nothing to momentum. Thus, it can be seen that some increase in velocity may be expected merely by achieving proper ignition.

It is felt that proper ignition of the 7 rounds at $+120^{\circ}F$ was not obtained because the cork plug blew out too soon. For proper ignition two conditions must be fulfilled - one, the quantity of black powder must be sufficient to envelope the propellant in flame, and two, the nozzle must be plugged sufficiently to allow pressure build-up in order to sustain the burning rate at the proper level. The limits within which these two conditions can be fulfilled are rather fine. For example, if one gram too much black power is used, the sticks can fracture resulting in either loss of propellant or a blow-up. Also, if the throat is plugged, a fraction too much, a blow-up will result, since the burning rate increases exponentially with pressure.

Since it was most important to obtain velocity data in this test, it was decided to use a minimum igniter and thus prevent motor blow-ups.

It was felt that three grams of FFFg black powder was a minimum load, while the 3/8" diameter hole in the 3/4" cork presented a minimum nozzle restriction. From the delayed and partial ignition obtained under these conditions, it may be concluded that the 3 grams of FFFg were sufficient (since ignition was accomplished) but the cork plug blew out too soon. Subsequent testing with rounds at -20°F using 5 grams of FFFg black powder further confirms the conclusion that the cork plug blew out too soon.

It is believed that proper ignition will be attained by using 3 grams of FFFg powder and a 3/4" cork without a drilled hole. Future tests will employ igniters of this type until such time as the combination igniter-nozzle closure can be manufactured and incorporated in the round.

3. Stability

The stability of the 7 rounds at /120°F was poor. The rounds began tumbling at somewhere between 40 and 80 yards range as visually observed. The range seemed satisfactory. For example, in zeroing in the launcher, one round was fired at a launcher elevation of 125 mils. This round carried, with tumbling, about 150 yards. Within the first 30 feet of flight as observed in the camera records, the round was stable with no sign of yaw.

The most obvious contributing factor to instability was the unfavorable location of the C. G., viz., 9 1/2" from the tail. The round length was 21" long. The reason for this was because of the motor metal parts being overweight as previously discussed. Modifications will be made to existing components of E. M. No. I to reduce weight aft and a flight test run to determine the effect on stability of a forward movement of the C. G.

Another contribution to instability may have been a reduction in the corrective force of the tail due to the bulkiness of the mid-section preventing sufficient air flow past and close to the tail. Modification to E. M. No. I to reduce weight aft will also somewhat reduce the mid-section area and improve air flow. However, a major reduction in mid-section cannot be made using E. M. No. I components, but it will be incorporated in E. M. No. 2.

Further evaluation of the aerodynamic configuration of E. M No. I has led to the suspicion that the ogive may be inducing a very large lift moment, therefore causing tumbling. Tests will be run with drag inducers on the ogive and with a modified ogive having a much longer cylindrical section and a larger radius at the tip, to check on this hypothesis.

In summary, it can be stated that although initial testing has shown E. M. No. 1 to be unstable, the flight characteristics indicate that a quick solution may be possible. Projecting the program, it is estimated that a stable round can be obtained before the end of October, providing the problems are not much more complex than they presently appear.

Following the flight test of 7 rounds at $\neq 120^{\circ}$F, 3 rounds were fired at -20°F. All of these rounds had such long ignition delays, that they fired after the camera had functioned, thus no velocity readings were obtained. However, from visual observation some general statements can be made.

The range of these rounds was slightly less than that of those fired at $\neq 120^{\circ}$F, which indicates that the velocity, impulse and specific impulse was commensurate with that expected at -20°F.

The igniter charge for these rounds was increased to 5 grams. Even with this increased load, 3 rounds failed to ignite, which confirms the conclusion that the poor ignition was due to the corks blowing out too soon. Furthermore, upon disassembly one stick of one of the charges which failed to ignite showed a crack on the nozzle end, running about 1" up the stick. This indicates that an igniter load of 5 grams is too large. It is felt that a load of 3 grams will produce proper ignition, with no damage to the propellant by properly plugging the nozzle.

The -20°F rounds were also unstable. The comments made previously on stability in the discussion of the /120°F rounds apply and need not be repeated here.

In regards to rounds fired at both /120°F and -20°F, no round was observed to burn out of the 3-foot launcher, thus confirming maximum burning distance estimates. Tests will be conducted using an open or rail launcher to determine actual burning distance, in order that the minimum launcher length may be established.

Two films, rounds No. 4 and 7 at /120°F, have been delivered to the Contract Officer by a member of the contracting agency.

Warhead Development Program (Drawing No. D-8012)

The warhead is to be capable of penetrating 10" of armour plate. Previous discussions in the Motor Development section have shown how a head O. D. of 2.5" and a head weight of 2 lbs. was developed (see paragraphs pp. 6,7).

The efficiency of the shaped charge effect is directly influenced by stand-off. Stand-off is defined as the distance between the base of the cone and the target at the instant the charge is initiated. Using a double angle liner, a stand-off of 1 1/2 cone diameter is a minimum requirement. The base diameter of the liner which has been designed is 2.435". The minimum stand-off distance is therefore 1.75 X 2.435 or 4.26".

In order to attain a stand-off of 4.26", allowance must be made for crush-up. Crush-up is defined as the distance the ogive is pushed in or crushed from the moment of target impact until the fuze functions, the very small fraction of time between fuze functioning and charge initiation being ignored. The amount of crush-up is dependent upon the strength of the ogive and the fuze functioning time. For preliminary design a fuze functioning time of 0.001 sec may be assumed as possible of achievement using the fuze discussed in the Fuze Development section. Assume also that the ogive offers no resistance to crush-up or in other words that the round continues at a velocity of 300 ft/sec for 0.001 sec. The maximum crush-up would then be 3600 in/sec X .001 sec or 3.6". Therefore, in order to obtain a stand-off of 4.26", the ogive must be 3.6" plus 4.26" or 7.86" long.

A crush-up of 3.6" is an assumed maximum. Actual crush-up should be less. How much less cannot be determined accurately by calculation. Also, the assumed functioning time of .001 sec is based primarily on static functioning, and this should be less when dynamically functioning, i.e., the set forward of parts at 300 ft/sec should reduce the functioning time.

Considering these factors an arbitrary ogive length of 6.550" has been chosen for the preliminary design, which allows for a crush-up of 2.29" and a stand-off of 4.26". Over-all round design allows as much increase in ogive length as would be necessary to obtain proper stand-off. Testing with live fuzes (i.e., detonator only) should present data to finalize ogive length.

Photograph No. 5 shows the metal parts of the HE head. Twenty-five sets of components have been manufactured and are presently being assembled. Comp B loading on this first lot will be done at the Hunter Corporation of Bristol, Pennsylvania. It is expected that 10 rounds will be statically fired during October to establish penetration data.

Launcher Development Program (Drawing No. D-8013)

The Launcher Program is approximately three weeks behind schedule as a result of a delay in receiving clearance on the Project Engineer, Mr. I. Ritucci.

However, since receiving clearance, a design layout has been made of the launcher, including sight, handle, igniter and safety pin. These assemblies are currently being detailed and manufactured. Thirty 3' long launcher tubes have been ordered.

When the assemblies and tubes have been received and the first mock-ups made, a detailed description will be given with photographs to illustrate the parts. This discussion will be presented in the October program report.

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Fuze Development Program (Drawing No. D-8014)

The basic fuze has been designed, and a 10-times-size layout made to determine the physical size of the parts. Detail drawings of the prototype fuze were prepared and two complete models made. Static tests were carried out on the two models and drawings and parts revised to facilitate assembly. A test was carried out to determine fuze sensitivity, functioning time and train functioning on target.

Since this is the first progress report, a detailed description will be given of the operating principles and assembly procedures. In order to maintain continuity the work done will be discussed under the following headings:

1. Operating Principles.
2. Assembly Procedures.
3. Tasks and Test Program.
4. Fuze Tests.
5. Future Program.

1. Operating Principles

As proposed, a simple mechanical fuze is being developed. Initiation of the detonator is obtained by penetrating it with an inertia and spring-driven firing pin. The spring load is obtained partly by pre-stressing the spring at assembly and partly by inertia. Delayed arming is obtained by the use of a rotor which is brought into the "armed" position by a torsion spring.

Reference is made to Drawing No. B-8076 which shows an assembly drawing of the fuze. Section AA of this drawing shows a cross-section through the fuze. Part B 8035 is the outer housing containing all the fuze components. An inertia element (A-8038) contains three balls which hold the firing pin from going forward by means of a groove in the firing pin and a sleeve (A-8039). The balls are placed at 120° from each other (not shown on the drawing). As can be seen, the firing spring is contained between the base of the firing pin and part A-8040 (exp, cover). A groove in the inertia element (A-8038) contains a snap ring. As shown, the parts are in the safe position since the firing pin cannot move forward. It may also be noted that in this position the rotor is held in the unarmed position by the firing pin. The detonator is at right angles to the axis of the round.

When the round is launched, the acceleration tends to move all parts of the round back toward the tail. This force is used to cock and arm the fuze. Henceforth, this force will be referred to as "Set-Back".

While all the other components of the round are solidly tied together, the triggering components of the fuze can be moved backward by compressing the firing spring. The following components are meant by "triggering components":

The sleeve, A-8039

The inertia weight, A-8038

The balls

The firing pin

The firing spring to the extent to which it is being compressed

The cock spring, A-8072

The fuze housing (B-8035) has an internal shoulder behind the lock spring (A-8072). When the triggering parts move back, the lock spring opens up and prevents the inertia weight from moving forward.

The following situation then exists:

All triggering parts are in the cocked (back) position. The firing spring exerts force against the firing pin. This pin cannot move forward because the balls lock between the groove in the pin and the internal diameter of sleeve A-8039. However, if the sleeve, A-8039, were removed, the balls would move outward, and the firing pin could then travel into the detonator. The force holding the sleeve, A-8039, in position is a component of the spring force. It creates friction force which has to be overcome when the sleeve is removed. Target impact or jolting of the round due to graze impact will produce forward motion of the sleeve and thus start the firing pin on its way into the detonator. Drawing No. A-8090 shows the steps as described in this discussion.

The following computations were used to determine the weight of the triggering parts of the fuze and the spring to be used. If we assume that

v_f = terminal velocity (muzzle velocity) = 300 ft/sec

v_o = initial velocity ($v_o = 0$), velocity at $t = 0$

a = acceleration ft/sec/sec

t = time (sec) burning time

s = distance (feet)

$t_1 = .012$ sec ($+120^{\circ}$F) minimum

$t_2 = .020$ sec (-20°F) maximum

$v_f = v_o + at$

300 ft/sec = a .020

$\frac{300}{.020} = 15{,}000$ or 466 gs

$\frac{300}{.012} = 777$ gs

$F = ma$

$F = \frac{W}{\cancel{g}} K\cancel{g}$

$F = WK$

W = expected weight of triggering components

$K_1 = 466$ minimum

$K_2 = 777$ maximum

Therefore,

F min. = 466 (.08) = 3.72 lbs.

F max. = 777 (.08) = 6.22 lbs.

The spring and triggering components were designed accordingly.

The arming delay spring is being designed to give the fuze an arming distance of approximately 5 feet from the launcher during which the fuze is safe. Assuming a velocity of 300 ft/sec, a distance of 5 feet will be covered in a time of approximately 0.0168 seconds. The rotor starts turning as soon as the firing pin is withdrawn. It may be assumed that this happens about half-way through the launcher. It would be desirable to have a longer delay. Experimental springs were made up by hand and their action compared to a photographic shutter.

A spring was chosen which should give a delay of about 0.025 seconds. A fixture was designed which will enable us to statically determine arming time using different springs. (See photograph No. 6)

This fixture enables the operator to place a rotor on a shaft which is identical in weight to the shaft used in the fuze. A slot in the shaft and one in the fixture make it possible to drive the rotor in the same manner, in which it is being driven in the fuze. The time taken to complete arming can then be determined either by taking high speed motion pictures or by the use of a chronograph. The rotor is held and released by a solenoid-operated pin (photograph No. 6).

Photograph No. 7 shows the fuze components to give some idea of their size. The housing (lying on top of the ruler) contains all components and therefore its contour is identical to the over-all contour of the fuze.

A slot on the side of the housing allows for safety pin behind the inertia element (A-8038), thus making the fuze extremely safe until the pin is removed. This mechanism is in process of being designed, and it is expected that details and the first set of experimental components will be available in the latter part of October. The safety wire will be pivoted in such a way as to make the fuze operable by pushing a small rod into the body of the round. When this problem is carefully considered, it appears that this is by far the best method, since any pins projecting from the round have to be out of the way when it leaves the launcher. At this point the fuze program and the launcher program have worked very closely together and the method of pushing the safety pin into the "Ready" position has been attended to in the preliminary launcher layout. However, neither a detailed layout nor detail drawings are available at this point.

2. Assembly Procedures

Section BB on Drawing No. B-8076 shows the method used to support and drive the rotor. Rotor shaft, A-8034, has a hole which corresponds to the detonator hole in the rotor. A slot is provided in this shaft to drive the shaft and rotor as one piece by means of a torque spring (A-8037). The rotor is assembled by pushing the shaft through the holes in the housing and through a central hole in the rotor. This hole as well as the section of the rotor shaft engaging same are D shaped to key the rotor and the shaft into the proper relationship. When this operation is complete, the rotor shaft and the rotor are staked together with a three-point staking tool. Experiments will be carried out to determine whether the D shaped sections on rotor and rotor shaft can be omitted and the parts properly assembled by staking only. In this case a locating pin will have to be placed in the detonator hole during assembly.

The assembly of the triggering components is self-evident on the assembly drawing. A photographic or movie record of this assembly procedure will be included in future reports.

The joining of the fuze to the round has been planned for in designing E. M. No. 2. The slot in fuze housing, B-8035, is used to line up the fuze. The barrier between the head parts and the motor on one side and the booster on the other locate the fuze along the axis of the round. A ring between the internal diameter of the head body and the external diameter of the fuze will give axial alignment. The above method should make it extremely simple to assemble the fuze into the rocket.

Drawing No. B-8079 shows the assembly of the detonator staking fixture. With the rotor held in the unarmed position, the detonator hole is at right angles to the axis of the fuze. The drawing shows how the fuze is held in the fixture. Any arbor press can then be used to accomplish the staking operation.

3. Tasks and Test Program

With a fuze of this design the following problems must be solved:

A. Functioning of firing mechanism

B. Cocking of trigger components

C. Arming

A. Functioning of firing mechanism

Assuming that the fuze has armed and the triggering components have set-back, the question becomes one of whether the firing pin will have the energy and correct configuration to initiate the stab type detonator. The pin will be driven into the detonator with a force of at least 4 lbs. (based on the pressure obtained from the spring). By past experience this should be more than sufficient. The shape of the pin was studied when the original fuze layout was made. Stab type detonators are best initiated by a pin having as many sharp cutting edges as possible. For this reason a four-sided pin has been chosen, and no more than .007 flat or radius will be allowed at the point. This design closely resembles current Italian practice.

The next problem with point A is functioning on graze. This will be determined by the energy required to remove the sleeve (A-8039). This is, in turn, determined by the spring force. However, by changing the shape of the sleeve (introducing a slight angle at the point where the balls touch), this force may be reduced to almost any desired value. Starting out with a zero angle, static tests were conducted, and it was found that the sensitivity was satisfactory, i.e., the fuze would fire when dropped from as little as 5", which is, of course, a vastly smaller figure than anything likely to be encountered by this round on graze. It is important to bear in mind that too great sensitivity must be avoided so that the round does not go off when touching branches, etc.

The functioning time of the fuze also belongs under this heading. It is of extreme importance, since it will directly affect the ogive configuration and penetration. It is assumed that zero functioning time is the ideal, i.e., the fuze functions at the same instant in time that the nose of the round makes contact with the target. This is practically impossible. However, any fuze on this type of round will have to try to come as close to it as possible.

Tests conducted with the Potter chronograph have shown that the distance between the detonator and the point of the firing pin has the strongest influence on the functioning time of this type of fuze. In the basic design this distance has therefore been kept to what was considered the practical minimum (.050"). As will be seen in the next section of this report, two test fixtures have been designed and manufactured in order to find out what the functioning time will be under actual operating conditions. As a starting point .001 of a second has been assumed to be acceptable and attainable. The test results so far have proven this to be correct.

B. Cocking of triggering components

It has to be established whether the triggering components will actually set back and latch into position. It is also of importance to find out whether upon doing this the sleeve (A-8039) will be thrown off and the firing pin thus prematurely released. Accumulation of tolerances in the fuze parts plays an important role here, since the amount of overtravel will vary with variations in the parts.

The term overtravel should be defined, since it will be very often used. It takes time for the snap ring to open after it travels beyond the shoulder in the fuze housing. In order to allow this time, it is necessary to allow the snap ring to travel back beyond the latching shoulder. The firingspring will push the triggering components forward as soon as acceleration ceases. The distance that the triggering components travel forward until the snap ring engages the shoulder is called overtravel. Tolerances on the various parts will have the tendency to add to this overtravel. If the overtravel is great enough, it could cause premature firing. The reason for this is as follows: When the firing spring begins to act on the triggering components (after acceleration is over), it will make them reverse the direction taken on set-back and push them as far forward as possible. We then have three possibilities:

1. The snap ring is not beyond the shoulder, and all components will return to the original position. The fuze will then never fire.

2. The overtravel as described above is too great, in which case the velocity imparted to the assembly by the spring will be too great, and when the inertia element stops, the deceleration will be sufficient to throw off the sleeve.

3. Overtravel is within the correct limits. Fuze will operate satisfactorily.

Since the rotor is held in the unarmed position by the firing pin, the functioning of the triggering components is essential to rotor functioning. This implies that testing with a rotor may give results which are hard to evaluate. For this reason preliminary tests will be held without a rotor and with an armed detonator in front of the firing pin to allow easy diagnosis of points discussed above.

C. Arming

This problem is merely to establish a rotor configuration which will turn into the armed position as soon as the firing pin sets back. This will have to happen with 100 per cent reliability.

In addition, the time taken by the rotor to reach the armed position will have to be in excess of the time taken by the rocket to cover the desired arming distance. The arming distance is that initial part of the rocket's flight during which it could hit a target without the explosive elements being initiated.

4. Fuze Tests

Two test fixtures were designed, detailed and manufactured during the month, apart from the arming delay fixture shown on the photograph in section 3. Static tests were conducted to assure that the fuze would assemble and function as planned. Drawing No. B-8049 shows the first of the fixtures. The second one was merely an improvement on the first using the same principle.

The object of these fixtures is to separate the triggering components from the arming components of the fuze so that their functioning may be determined without being affected by the way the arming components function. The triggering components were assembled in the set-back position, and the triggering sleeve positively prevented from setting forward by a safety pin (for ease of assembly and safety of personnel in running the test). The fixture contained a detonator in the armed position. The location of the detonator corresponded exactly to the armed position in the complete fuze. This fixture was dropped from a height of 12" to determine

(a) Functioning of the triggering components on very light impact.

(b) Functioning of detonator with the firing pin driven by the spring chosen for this design and with the firing pinpoint chosen.

(c) Functioning time of the fuze (high-speed camera).

Two tests were conducted during the reporting period. The first was held on 26 September when two test fuzes were dropped as described. The second test was run on 4 October when an additional test vehicle was dropped.

The results in all three cases were positive:

(1) All three fuzes functioned on impact.

(2) Train functioning between the firing pin and the detonator is satisfactory.

(3) The functioning time of the fuze appears to be in the neighborhood of .001 seconds.

In addition to the above tests two complete sets of parts of the prototype fuze have been manufactured and assembled. Some minor difficulties were experienced in the assembly and the drawings modified accordingly.

FUTURE PROGRAM

It is planned to go immediately into a series of dynamic tests to establish functioning of the triggering components. Past experience has shown that the problems are in the order of importance and of the nature of the ones outlined above. It is therefore possible to proceed in an orderly way of first establishing the functioning and time of functioning of the triggering components. While this is taking place, the fixture for determining arming time will be used to find the right torque spring. When this is accomplished, complete fuzes will be fired. The safety pin and the method of operating it will then receive concentrated attention.

At the present time a test fixture is being designed which will place a detonator in front of the firing pin without the use of a rotor. In order to do this, the distance between the firing pin-point and the detonator will have to be increased. This is due to the fact that, when in the storage position of the complete fuze, the firing pin is so far forward that it would penetrate the detonator were the fuze armed. The reason for this design is, of course, the necessity to reduce firing pin travel to the point of contact with the detonator to a minimum. Slightly longer functioning times can be expected from the test configuration than from with the final fuze.

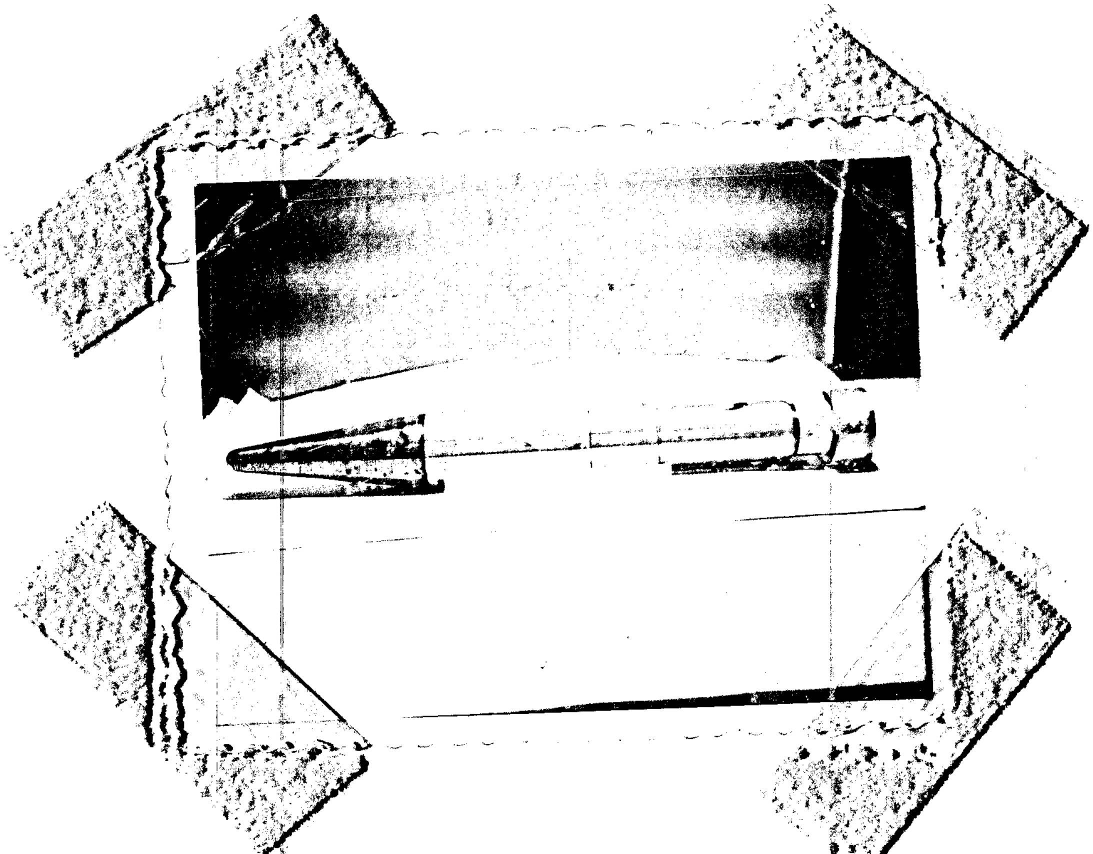
REFERENCES

Reference 1 - See definition of Specific Impulse on page 8.

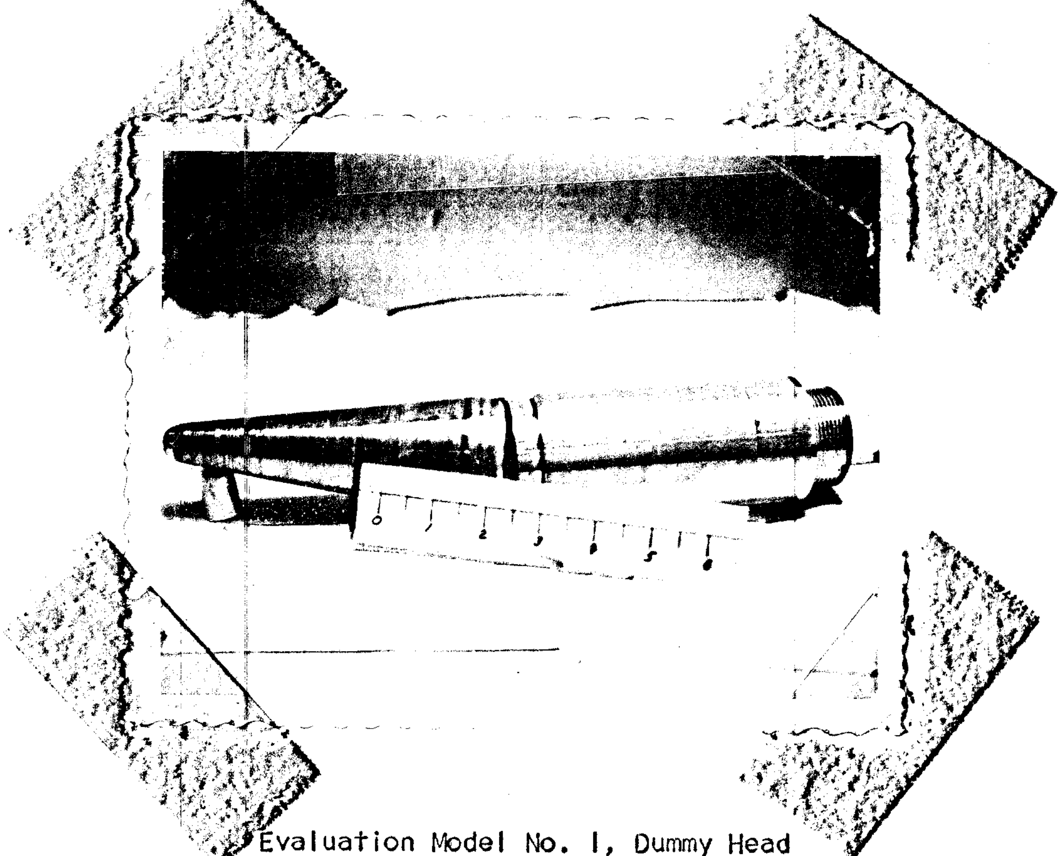
Reference 2 - Hesse-Eastern Final Reports on Contract No. DAI-19-020-501-ORD-(P)-24, Rocket, Heat, 3.5" T230 and Practice, T233, and Contract No. DAI-19-020-501-ORD-(P)-34, Grenade, Rifle, Heat, T51 and Fuze, Grenade, Rifle, T1023

Reference 3 - Hesse-Eastern Final Report on Contract No. DAI-19-020-501-ORD-(P)-22, 2.36" Caliber Shaped Charge Rocket Head

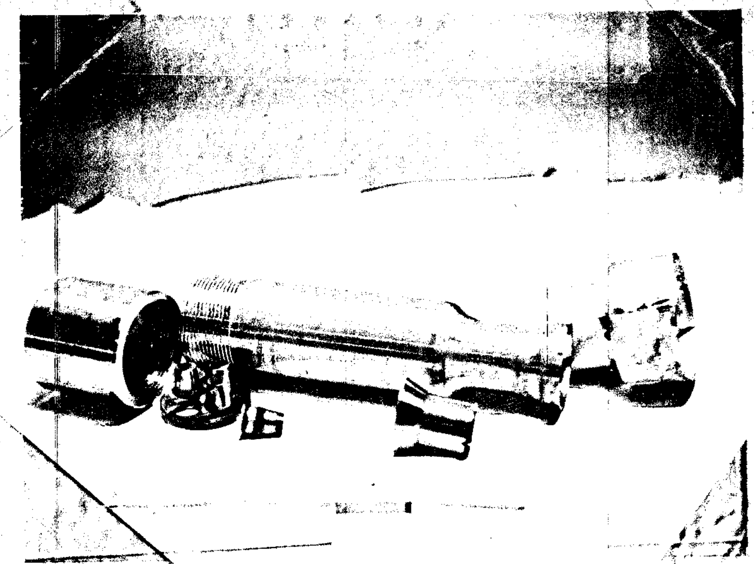
APPENDIX



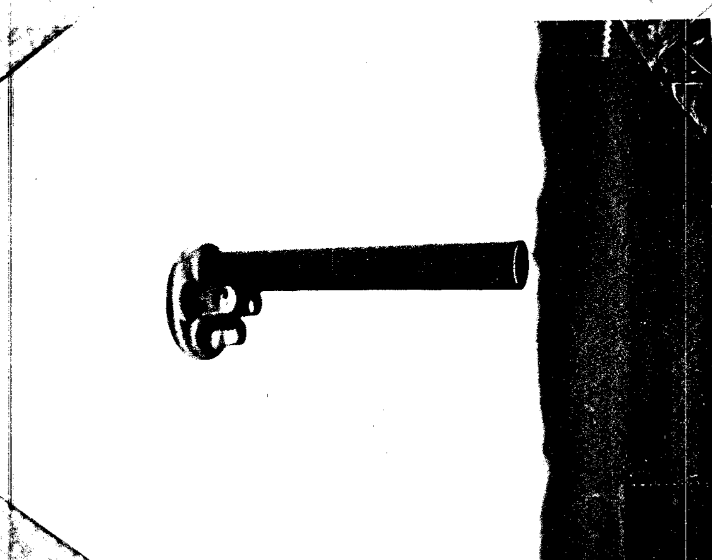
Evaluation Model No. 1, with Dummy Head
Photograph No. 1



Evaluation Model No. 1, Dummy Head
Photograph No. 2

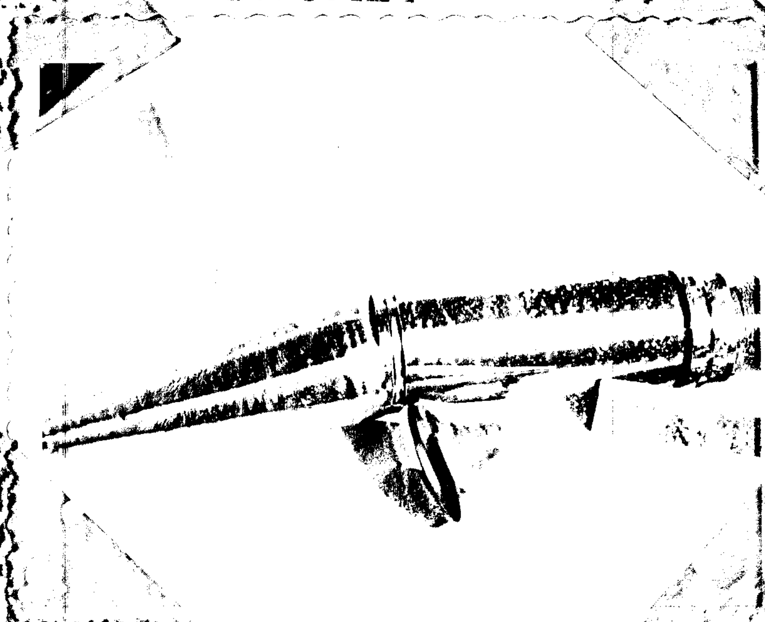


Photograph No. 3
Evaluation Model No. 1, Motor Metal Parts

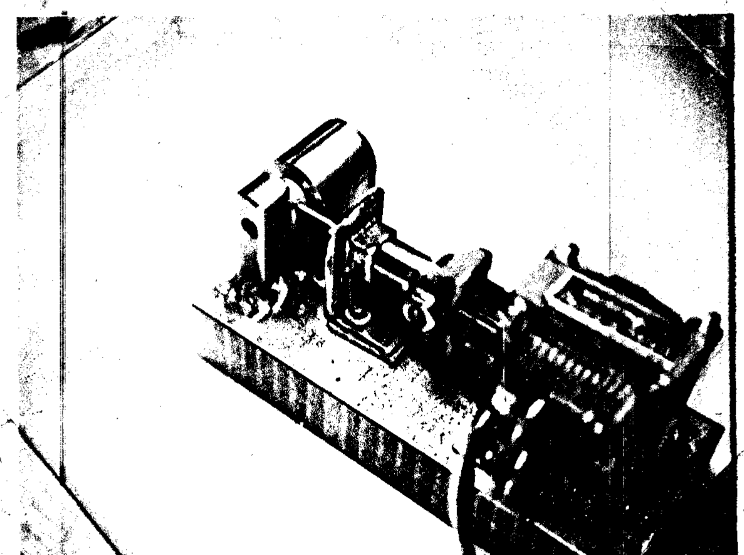


Evaluation Model No. 1, Propellant Charge
Photograph No. 4

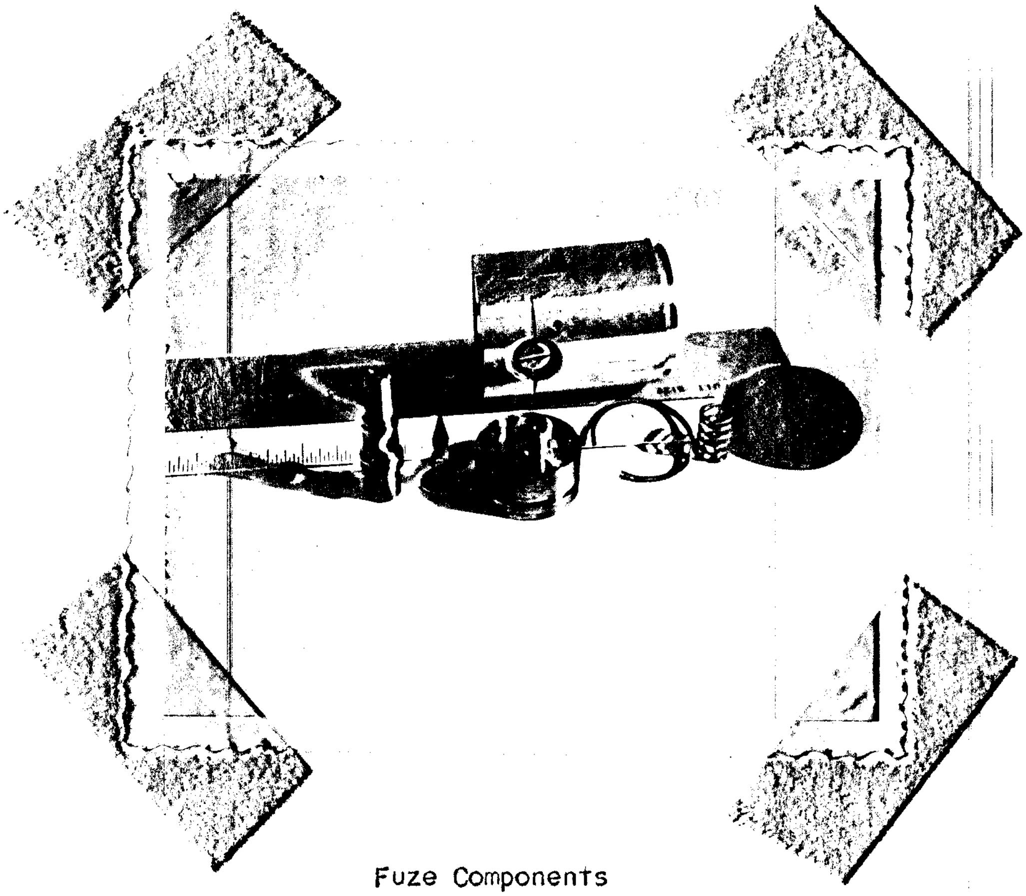
SECRET



Evaluation Model No. 1, Heat Head
Photograph No. 5

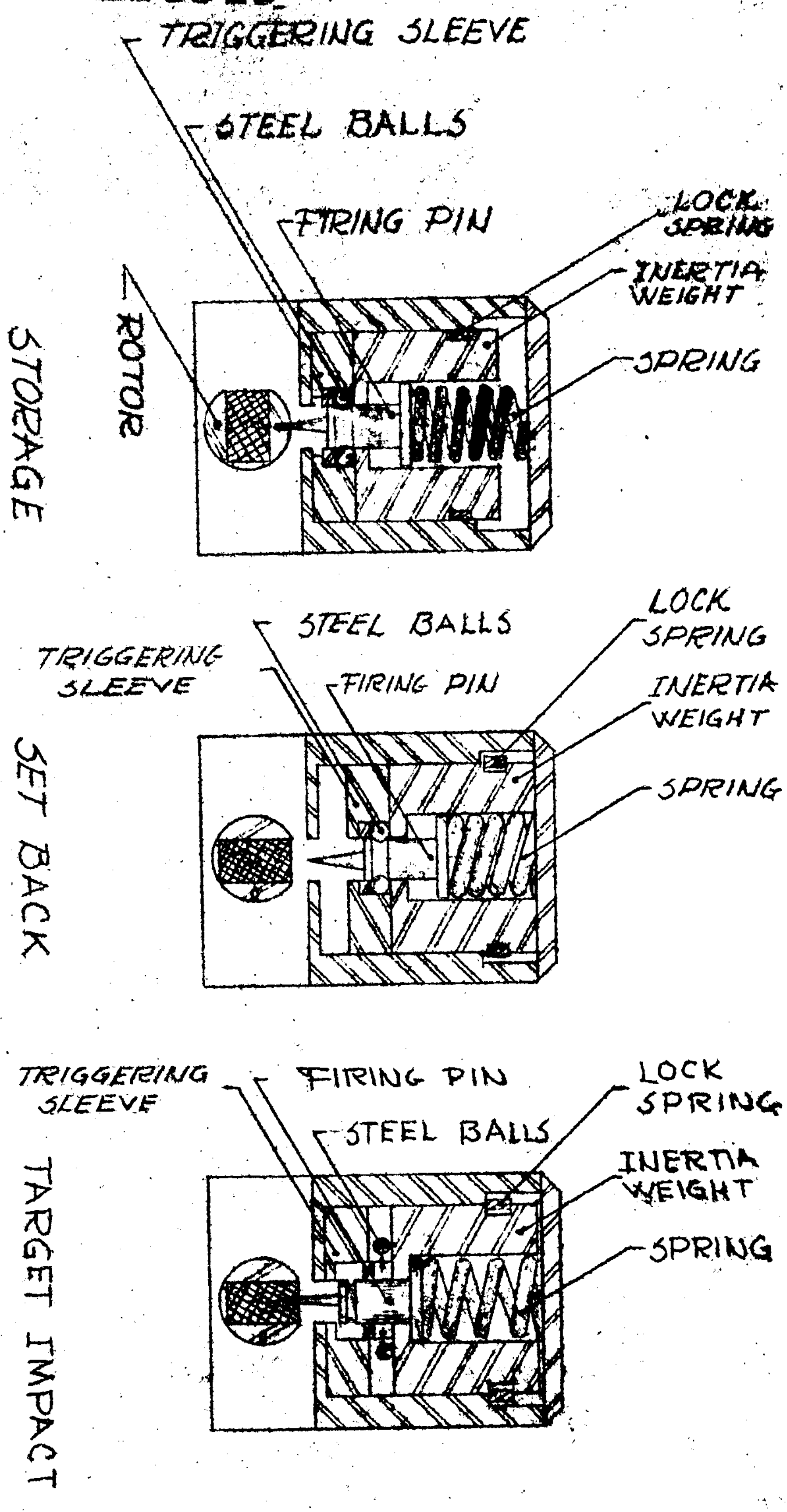


Fixture to Determine Arming Time
Photograph No. 6



Fuze Components
Photograph No. 7

SECRET



REVISIONS

DO NOT SCALE DRAWING

ALL DIMENSIONS APPLY AFTER PLATING

125 FINISH ALL OVER EXCEPT WHERE NOTED

BREAK ALL SHARP CORNERS .005—.010

STANDARD TOLERANCES

DECIMAL	±.005
FRACTIONAL	±1/64
ANGULAR	±1°
ALL DIA. ON SAME ¢ TO BE CONCENTRIC WITHIN	T.I.R.
UNLESS OTHERWISE NOTED	

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CAMBRIDGE 38, MASS.

FUZE OPERATING SCHEMATIC

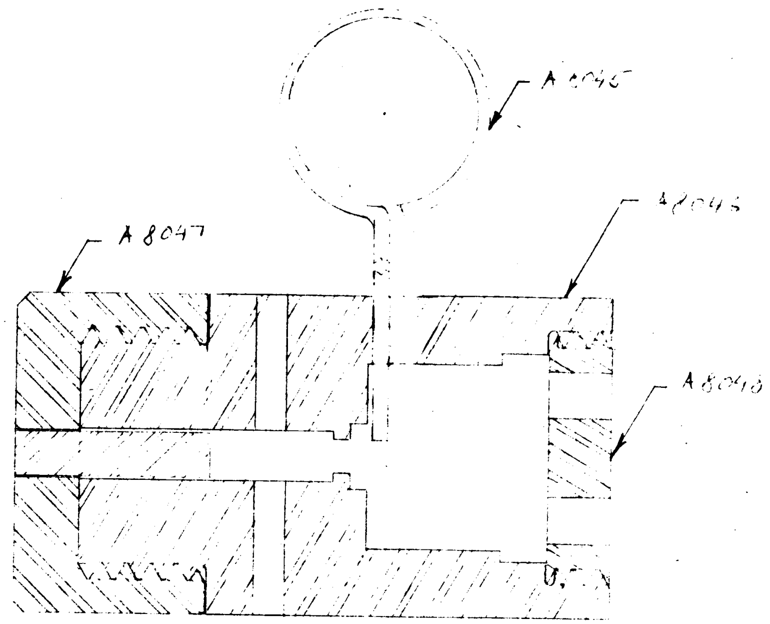
PROJ. 50G-1
ASSY DWG
SCALE NONE
REF DWG
MAT'L SEE DETAILS

BY KAW 10 11 57
CH'K'D
ENG'R
APP'D

A 8090
REV. 0

SECRET

SECRET



PARTS LIST

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A8046		HOUSING	1
A8045		SAFETY PIN	1
A8047		TH'D. COVER	1
A8048		TH'D. CAP	1

REVISIONS

DO NOT SCALE DRAWING

ALL DIMENSIONS APPLY AFTER PLATING

125 FINISH ALL OVER EXCEPT WHERE NOTED

BREAK ALL SHARP CORNERS .005—.010

STANDARD TOLERANCES
DECIMAL ±.005
FRACTIONAL ±1/64
ANGULAR ±1°
ALL DIA. ON SAME ℄ TO BE CONCENTRIC WITHIN T.I.R.
UNLESS OTHERWISE NOTED

HESSE—EASTERN, DIVISION OF FLIGHTEX FABRICS, INC.
CAMBRIDGE 38, MASS.

ASS'Y. TEST FIXT.
FUZE TEST #1

PROJ. 50G-1 | ASSY DWG
SCALE 2:1 | REF DWG
MAT'L.

BY	E. Z.	9-16-5[illegible]
CH'K'D	[illegible]	9-19-5[illegible]
ENG'R		
APP'D		

B [illegible] REV. 0

SECRET

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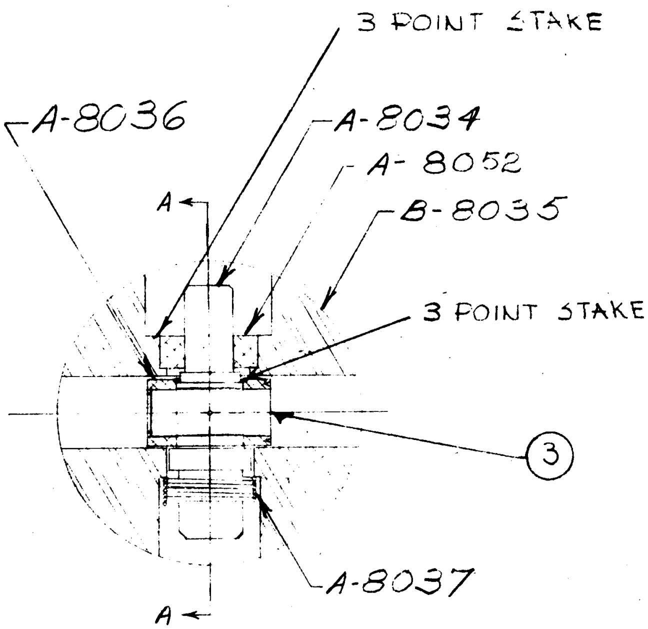
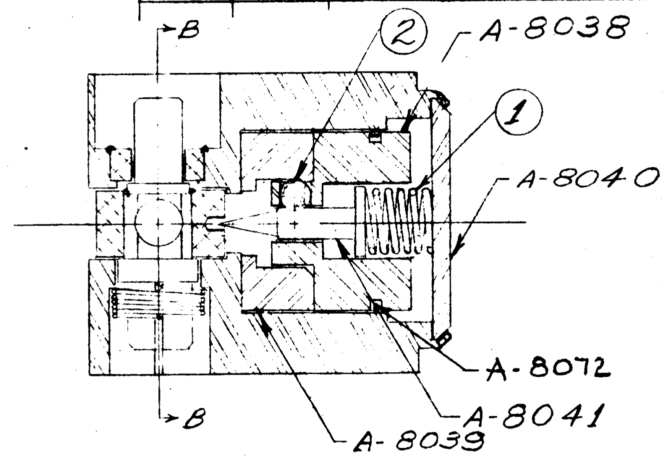
SECRET

PARTS LIST

	DWG.#	ITEM#	DESCRIPTION	QUAN.
*		1	SPRING.- 3/8 LONG, .031 WIRE, 1/4 OD.	1
*		2	.125 DIA. STEEL BALL	1
	A-8034		ROTOR, SHAFT	1
	A-8052		SHAFT BEARING	1
	A-8036		ROTOR, EXP.	1
	A-8037		TORSION SPRING EXP	1
*	A-8038		INERTIA WEIGHT	1
*	A-8039		TRIGGERING SLEEVE	1
	A-8040		EXP- COVER	1
*	A-8041		FIRING PIN - EXP	1
	B-8035		HOUSING EXP.	1
*	A-8072		LOCK SPRING	1
		3	T57 DETONATOR STAB TYPE	1



SECTION B-B



SECTION A-A

* TRIGGERING COMPONENTS

REVISIONS	
DO NOT SCALE DRAWING	
ALL DIMENSIONS APPLY AFTER PLATING	
125 FINISH ALL OVER EXCEPT WHERE NOTED	
BREAK ALL SHARP CORNERS .005—.010	
STANDARD TOLERANCES	DECIMAL ±.005; FRACTIONAL ±1/64; ANGULAR ±1°
ALL DIA. ON SAME ℄ TO BE CONCENTRIC WITHIN T.I.R. UNLESS OTHERWISE NOTED	

HESSE—EASTERN, DIVISION OF FLIGHTEX FABRICS, INC. CAMBRIDGE 38, MASS.	BY	L. Z.	9-23-57
ASS'Y.- FUZE	CH'K'D	T.F.	10-2-57
	ENG'R		
PROJ. 50G-1 / ASSY DWG	APP'D.		
SCALE 2:1 Approx / REF DWG	B	8076	REV.
MAT'L. SEE DETAILS			

SECRET

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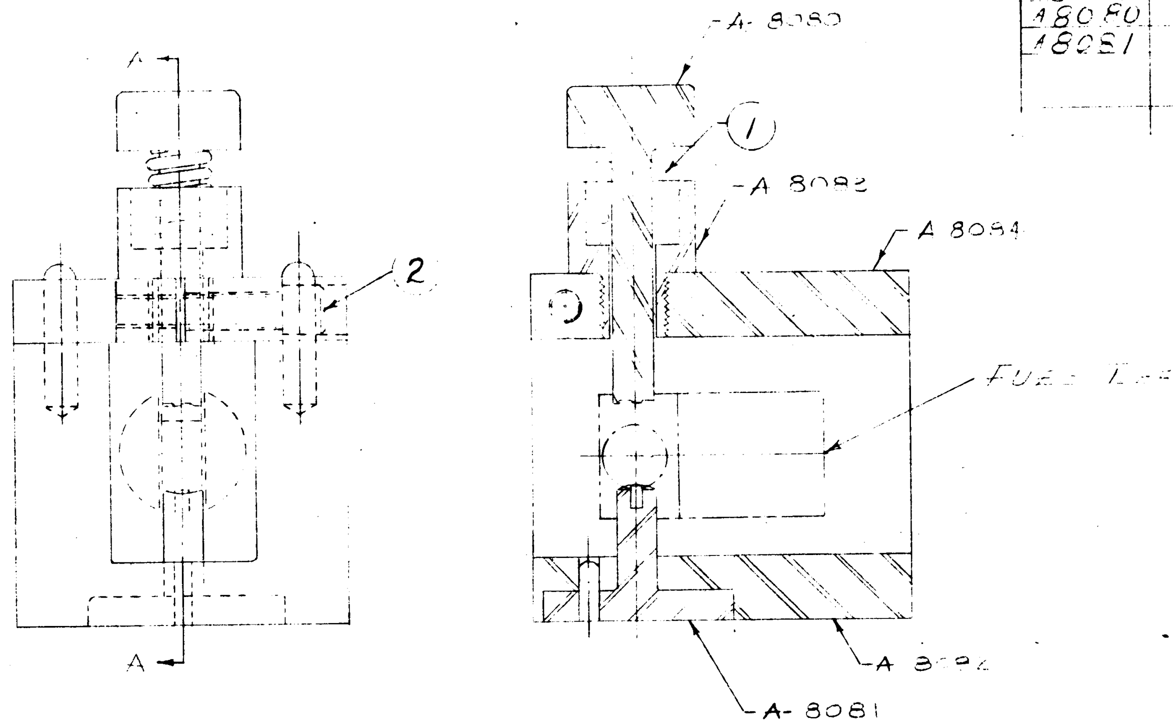
SECRET

P/L LIST

DWG #	ITEM	DESCRIPTION	QUAN
A8084		CAP	1
A8082		BASE	1
A8083		GUIDE RAM	1
A8080		3 POINT STAKE	1
A8081		ROTOR SUPPORT	1
	1	ST'D COMP SPRING -.062 WIRE DIA 3/4 LONG	1
	2	[illegible] X 1/2 [illegible] Screw	1



SECTION "A-A"

REVISIONS
DO NOT SCALE DRAWING
ALL DIMENSIONS APPLY AFTER PLATING
125 FINISH ALL OVER EXCEPT WHERE NOTED
BREAK ALL SHARP CORNERS .005—.010
STANDARD TOLERANCES DECIMAL +.005 FRACTIONAL ±1/64 ANGULAR ±1° ALL DIA ON SAME ℄ TO BE CONCENTRIC WITHIN T.I.R UNLESS OTHERWISE NOTED

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OF FLIGHTEX FABRICS, INC.
CAMBRIDGE 38, MASS.

ASSY ROTOR STAKING FIXTURE

PROJ. 50G-1	ASSY DWG
SCALE 1:1	REF DWG
MAT'L. SEE DETAILS	

BY	[illegible initials]	10 3 57
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